Innovation in electropolishing: Greater selectivity and definition with DryLyte dry electropolishing

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In recent years, the interest for dry electropolishing has increased due to its excellent finishing quality, ease of use, biocompatibility, corrosion resistance, fatigue life, and resistance to erosion and premature aging, amongst other features.

From the first patent for classic electropolishing through the revolutionary new process of dry electropolishing, the basic chemical process has not changed. Electropolishing is a specific type of electrolysis that involves a direct electrical current that passes through an electrolyte in an electrolytic cell. The piece of metal to be polished serves as an anode, connected to a positive terminal of a direct current power supply, with the negative terminal connected to a cathode. The piece and the cathode are immersed in an electrolytic medium, Fig.1. Activating the power supply produces an electrical current that goes through the anode to the cathode, which results in oxidation on the metallic surface. These oxides that are formed are then dissolved, which eliminates the material on the surface and produces a smooth and polished effect.

With the innovation of the new patented DryLyte process, for the first time in more than 85 years, the electrolytic medium is no longer a dissolution of concentrated acids. Instead, in the DryLyte process, the liquid acids are replaced with a set of tiny solid spheres with the capacity to conduct electricity.

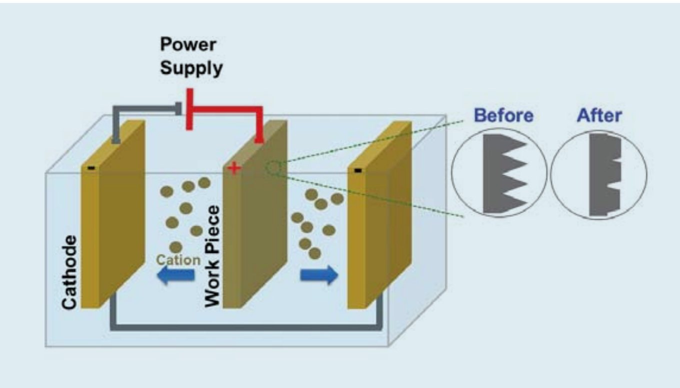
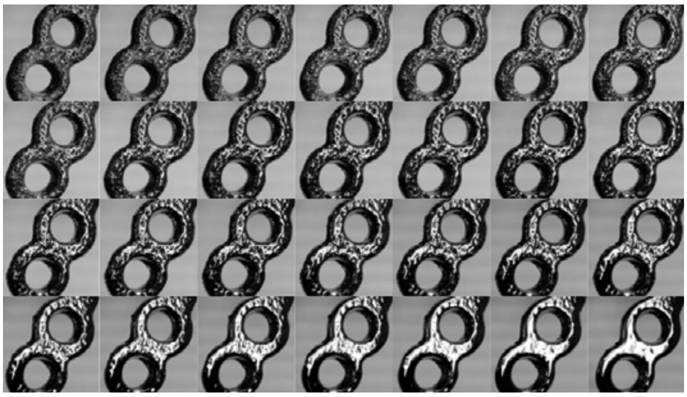


Fig 1: Diagram of the electrolysis process in electropolishing



Macro sequence of a DryLyte Technology Polishing Process.

CONVENTIONAL ELECTROPOLISHING

In classic electropolishing, the liquid acid solution contacts with both peaks and valleys of roughness, so it produces an effect on the entire surface. The smoothing process occurs because 1) the peaks of roughness receive more electricity, therefore they oxidize more and 2) the dissolution of oxides in the valleys is limited because of a lower diffusion rate. Both effects are gradual, and do not produce a complete differentiation between roughness peaks and valleys. To reduce the difference between the peaks and valleys to create a smooth surface, it is necessary to dissolve a quantity of metal much higher than the theoretical minimum. Since the borders, edges and geometric vertices of the part receive more electricity, this is where excessive variations in dimensions can occur, especially for applications requiring precision or sharp edges. This creates a lack of efficiency since part of the energy, current and time is wasted in extracting material of roughness valleys, without causing a decrease in overall surface roughness.

The electrolytes used for electropolishing are often concentrated acid solutions that have a high viscosity, such as sulfuric acid mixtures and phosphoric acid. Other electropolishing electrolytes reported in literature include perchlorate mixtures with acetic anhydride and methanolic sulfuric acid solutions. The use of highly concentrated electrolytes is one of the biggest practical drawbacks of conventional electropolishing. It requires additional safety measures to be put in place for proper disposal, personal protection, and environmental concerns.

DRY ELECTROPOLISHING DryLyte

The DryLyte electropolishing process was introduced to overcome the limitations of classic electropolishing, and to bring improvements to the process. This is a new patented technology based on a set of solid electrolyte particles with the ability to conduct electricity and to remove the oxides produced during the electropolishing process. Unlike traditional polishing systems, the DryLyte system obtains a uniform finish avoiding marks on the surface, patterns like those generated by machining, and is capable of processing complex geometries without generating micro scratches on the surface, Fig 2.

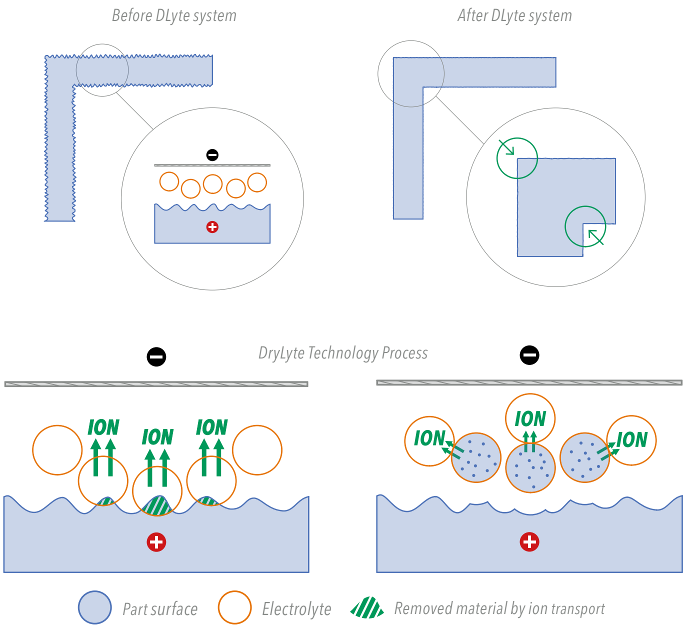


Fig 2: DryLyte process diagram. The material is extracted only from the peaks of roughness, without affecting the overall dimensions of the piece.

In this process, the medium is formed by a set of spheres of non-conductive polymeric material that is capable of retaining liquid electrolyte without it being able to escape. When contacting a surface, the sphere can only contact the peaks of roughness, and it is only at these contact points that the oxidation and removal of metal occurs. In this way, the polishing is highly selective, and is better able to maintain the geometry of the piece. Fig 3. This selectivity allows dry electropolishing to achieve the same roughness reduction as liquid electropolishing while removing less metal overall. This feature is especially important in parts with high precision finishes, tools that require a sharp edge, such as knives, bits, and milling cutters, and in jewelry applications to preserve valuable metal.

A limitation of a particle medium relative to a liquid medium is that it is not fluid. This solid electrolyte, made up of macroscopic solid particles, behaves like a granular material in which the force of friction between particles dominates the energy dissipation. These types of materials have behaviors that can mimic a solid or a liquid depending on the set of forces and movements to which it is subjected. For an ideal application as an electrolyte medium, it is usually preferable for the macroscopic behavior to have a more fluid movement. Any system utilizing the DryLyte process must ensure movement between the surface to be polished and the solid electrolyte. This can be achieved through movement of the piece, container vibration, piece vibration, and injection of air stream, or a combination of the above.

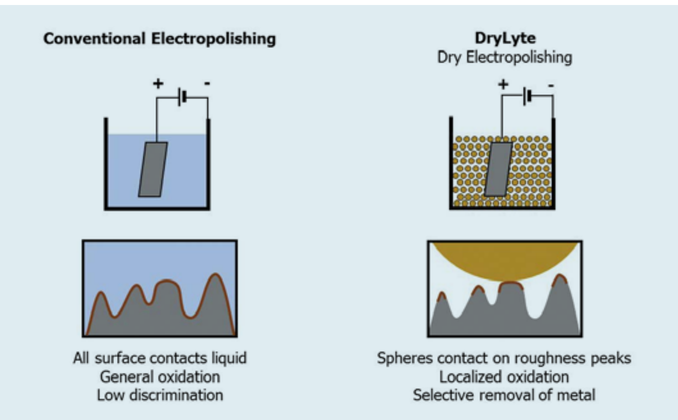


Fig 3: Schematic comparison between classic electropolishing and the DryLyte process.

The use of different particle dimensions minimizes the effect of not having a fluid, so, depending on the geometry of the piece, different particle size combinations are used, Fig 4.

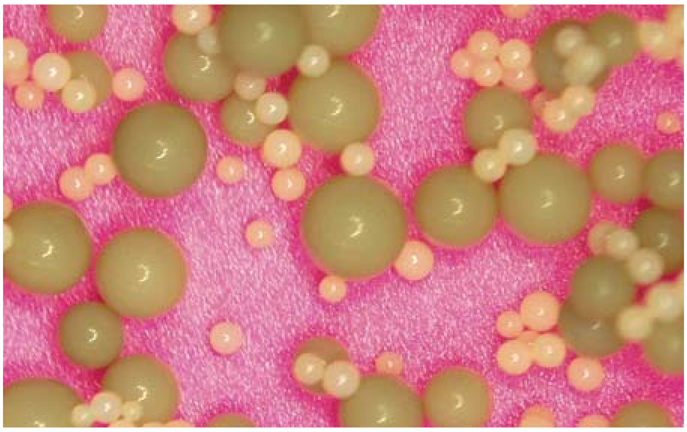


Fig 4: Solid particles of different size in the DryLyte process

In addition to surface uniformity, the DryLyte process offers a wide range of other benefits over traditional liquid electropolishing. These include increased corrosion resistance, fatigue resistance, resistance to erosion and premature aging, excellent biocompatibility, and improved adherence of subsequent coatings. All of this is achieved in a more environmentally friendly way while reducing the number of processes and therefore the total polishing time.

It is appropriate for a vast assortment of metals such as carbon steels, aluminum alloys, titanium, nickel, copper, cobalt chrome, and hard tool steels. Other materials being studied for its use are zamak, magnesium alloys, and tungsten carbide tool steels. These materials make it applicable in a wide variety of sectors such as industrial, aeronautical, healthcare, and jewelry.